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SENSORICAL QUALITY OF POTATO FINGERS FRIED IN DIFFERENT REHEATED OILS AND FATS

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ABSTRACT: *Potato fingers (French fries) were deep-fried in each of palm oil (P.O.); corn oil (C.O.); sunflower oil (S.O.) and butter fat "Ghee" (B.F.). Moreover, fingers were deep-fried in five blends of the aforementioned oils and fats as follows : Blend 1 (1 P.O. : 2 C.O. : 3 S.O. : 4 B.F.). ; Blend 2 (4 P.O. : 3 C.O. : 3 S.O. : 1 B.F.); Blend 3 (2 P.O. : 1 C.O. : 3 S.O. : 4 B.F.); Blend 4 (3 P.O. : 4 C.O. : 1 S.O. : 2 B.F.) and blend 5 (1 P.O. : 2 C.O. : 4 S.O. : 3 B.F.). Oils and blends were continuously heated at 180°C for 8 hours. Potato fingers were fried for 10 minutes and the last batch/frying hour was organoleptically evaluated. Data of sensory evaluation were statistically analyzed by ANOVA for factorial experiment with three factors (Reheating time, type of oil or blend and organoleptic property).*

Despite some diversity in quality of French fries fried in different blends, data revealed that potato French fries were significantly deteriorated by frying in all reheated oils and their blends. It was obvious that as reheating time was proceeded the organoleptic quality was dramatically declined.

Key Words: *French fries-palm oil-Corn oil-Sunflower oil-Butter fat "Ghee"-Oil blends.*

INTRODUCTION

Frying is one of the most popular methods for food preparation worldwide. Deep-fat frying is defined as a process of cooking and drying through contact with hot oil. Several chemical and physical changes occur in fried material during frying, including starch gelatinization, protein denaturation and water vaporization and crust formation (Pokorny, 1989).

Frying temperature and duration along with product shape play a role in oil retention and thereby quality of the fried foods (Fan and Arce, 1986). Meanwhile, it was demonstrated that the amount of oil absorbed by a product to be fried is independent of frying temperature (Gample *et al.*, 1987). In other words, elevation the frying temperature is not always beneficial as frying time is independent of oil temperatures in the range of 155 to 200°C, (Pravisani and Calvelo, 1986).

Nomerous research papers have been published regarding the deterioration of oils used in deep frying as a result of prolonged reheating (El-Sharkawy, 1979, Badwy, 1986, Clark and Serbia, 1991, Foda, 1998, El-Dessouky and Youssef, 2001). However, data concerning the sensorical quality of food fried in reheated oils are scare. Consequently, the present study was carried out to investigate the organoleptic properties of potato fingers (French fries) fried in different oils and their blends. Such oils and blends were reheated for different periods.

MATERIALS AND METHODS

Materials:

Representative samples (35 K. each of three different oils were kindly secured from Extracted Oils and Derivatives Company, Alexandria, Egypt. The oils investigated included palm oil, corn oil and sunflower oil. Fresh Butter fat "Ghee" was purchased from a farmer in Tanta city, Egypt.

Blends :

The aforementioned three vegetable oils along with butter fat were blended at ratios shown in Table (1).

Frying process:

Potato French fries were deeply fried in sufficient amounts of each of the three vegetable oils and butter ghee individually. Meanwhile, the fingers were fried in each of the oil blends mentioned in Table (1). A constant weight of 5 kg of each oil or blend was used in frying process at 180°C for 10 minutes. Frying was carried out continuously for 8 hours without a replenishment of oil amount that absorbed by potato fingers.

Sensory evaluation :

Six batches of potato French fries (1 k. fors each) were fried within a period of each hour of the total working frying period (8 hours). The last batch belonging to each frying hour was organoleptically evaluated by 10 well-trained panelists. They were asked to evaluate each of colour, taste, consistency and odour of French fries on the following hedonics scale: 1-2 (Very poor), 3-4 (Fair), 5-6 (Good), 7-8 (Very good) and 9-10 (Excellent).

Data of sensory evaluation were statistically analyzed by Analysis of Variance (ANOVA) for factorial experiment with three factors, namely: Time of reheating oil, type of oil and organoleptic property. These comparisons were conducted for the transfered data by taking the square root for the values of data after adding one, because the original data were terminilized and contained zeroes, specially for the 8 hour treatment. Analysis of variance was done for factorial experiment with 3 factors namely, blend type, heating time and organoleptic characters at different intervals (5, 8 and 4 hours, respectively) achieved as Randomized Complete Block Design (R.C.B.D) with

3 replicates. The means were compared by using the least significant difference test. "L.S.D test" as outlined by Snedicor (1958).

Table (1) :Blending ratios of some vegetable oils and butter fat (Ghee).

Oil Blends				
(1)	(2)	(3)	(4)	(5)
1 P.O.	4 P.O.	2 P.O.	3 P.O.	1 P.O.
2 C.O.	3 C.O.	1 C.O.	4 C.O.	2 C.O.
3 S.O.	2 S.O.	3 S.O.	1 S.O.	4 S.O.
4 B.F.	1 B.F.	4 B.F.	2 B.F.	3 B.F.

RESULTS AND DISCUSSION

Table (2) gives results of analysis of variance for factorial experiment with three factors; Time of reheating oil, type of oil and the organoleptic characters . The analysis revealed also the interaction between each two factors as well as the overlapping among the three factors. The experimental treatments showed a high significance level. Moreover , the partation revealed that all the three studied factors exhibited a high significance which proved that there is a real effect from one level for each factor to another affecting the organoleptic scores, as it would be distenguished later.

The three different interactions explored highly significantly effects which explained that the scores given by panelists were gained due to the effect to a certain factor besides the interaction with other factor as an addational effect. The second order interaction, among the three factors showed a high significance too, to add another source of variation effect. Therefore, the least significant differences (L.S.D.) were figured out to verify the differences between the factors` levels` means.

Table (3) summarizes the L.S.D. values with respect to the reheating time and the blends` means, besides the means belonging to the interaction between these two factors. The blends` mean differed significantly from each other and they were in descending order as follows: Blend-2 (2.982), Blend-3, Blend-4, Blend-1 and finally Blend-5 (2.336). Regarding the effect of frying time, it was clear that as the reheating time proceeded , the organoleptic scores decreased without any exceptions, while the greates value was for the 1st hour reheating mean and the least was for 8 hour regardless the other two factors (Blends & sensory characters). Owing to the significance of the interaction between blends and reheating time, the means of both factors (40 means) were compared. it was obvious that for Blends-1, 4 and 5, there were significant differences among the times mean's and they were in descending order as the time was proceeded.

TABLE (2). Analysis of variance for factorial experiment with three factors (blends, reheating time and organoleptic characters) achieved as randomizied complete block design with three replecates to test the effect of frying time on the organoleptic characters for five oil blends .

SOV	d.f	SS	MS	Fcal	F table
REP	2	0.001553026	0.000776513	1.601088 NS	3.83 , 6.64
TRETTS	159	140.1337042	0.881344052	1817.2391 **	1.12 , 1.19
Reheating time	7	92.9320091	13.2760013	27373.7239 **	2.03 , 2.69
Blends	4	25.13234956	6.283087389	12955.068 **	2.29 , 3.26
Organoleptic character	3	0.183165705	0.061055235	125.889498797 **	2.62 , 3.83
Time * Blends	28	15.62392661	0.557997379	1150.53214 **	1.49 , 1.74
Time* reheating time	21	1.070288934	0.05096614	105.086841 **	1.6 , 1.92
Blends* reh.time	12	1.430078194	0.119173183	245.72261886 **	1.85 , 2.37
Blend*T*a.time*chacter	84	3.761886144	0.044784359	92.3406565 **	1.28 , 1.42
Error	318	0.15422704	0.000484991		
Total	479	140.2894843			

		LSD(0.05)	LSD(0.01)
Sx (4)	0.00201037	0.005568726	0.007317748
Sx (5)	0.002247662	0.006226025	0.008181491
Sx (8)	0.002843093	0.007875368	0.010348859
Sx (20)	0.004495325	0.01245205	0.016362982
Sx (32)	0.005686186	0.015750736	0.020697718
Sx (40)	0.006357349	0.017609858	0.023140752
Sx (160)	0.012714699	0.035219715	0.046281503

NS Means non significant.

* Means significan at P. 0.05 .

** Means highly significan at P. 0.01 .

Table (3). The least significant difference test to compare the reheating time., blends and the interaction between the both factors.

Time / Blends	Blend-1		Blend-2		Blend-3		Blend-4		Blend-5		Time means	
1 HRS	3.221	A b	3.317	A a	3.317	A a	3.317	A a	3.317	A a	3.297	A
2 HRS	3.140	B c	2.961	E e	3.317	A a	3.240	B b	3.081	B d	3.148	B
3 HRS	2.840	C e	3.201	B a	3.162	B b	3.080	C c	2.914	C d	3.040	C
4 HRS	2.761	D d	3.122	C a	3.000	C b	2.936	D c	2.691	D e	2.902	D
5 HRS	2.548	E d	3.061	D a	2.826	D b	2.896	E c	2.118	E e	2.672	E
6 HRS	2.474	F d	2.915	F a	2.642	E c	2.691	F b	1.866	F e	2.518	F
7 HRS	2.000	G d	2.804	G a	2.448	F c	2.498	G b	1.494	G b	2.249	G
8 HRS	1.767	H d	2.473	H a	2.148	G b	2.030	H c	1.207	H e	1.925	H
Blends means	2.594	d	2.982	a	2.857	b	2.825	c	2.336	e	2.719	

Different letters means that there are significant difference between the means.

Capital letters to the vertical comparison and the small letters to the horizontal one.

$LSD\ (4)_{(0.05)} = 0.0055687$ $LSD\ (5)_{(0.05)} = .006226$ $LSD\ (8)_{(0.05)} = 0.007875$ $LSD\ (20)_{(0.05)} = 0.01245$ $LSD\ (40)_{(0.05)} = 0.01760$

Blend-2 showed an exception in this respect, where, the second hour, showed significantly lower mean in comparison with 1st, 3rd, 4th and the 5th hour means. Blend-3 showed 2 means without significant differences; at 1st and the second treatments . However, they were significantly higher than the rest treatments. In all the 8 hours treatments, Blend-2 had the greatest significantly means and they did not differe significantly from Blends-3, 4 and 5 in the 1st hour as well as they did not differe significantly from Blend-3 mean in the second hour treatment. The following Blend for most treatments, was Blend-3 especially in 3, 4 and 5 hour treatments and in 6, 7 and 8 hour treatments for Blend-4. The lowest organoleptic scores means were due to the Blend-5 in most cases except for 7 hour treatment which was the second higher mean. Fig (1) verifies these results which indicate that Blend-2 had the greatest means, where as Blend-5 had the lowest one. Moreover, the least value was belongings to blend-5 in the 8 hour treatment. The results established that as the time of reheating was elongated , the character means declined, and the Blend-2 had the highest resistance to the three variables and still the highest in most cases .

Table (4) represents the results of L.S.D. test for the character's means, blends and the means of the interaction between them. Regarding to the characters` , colour means was significantly the greatest, however the other 3 characters' means did not significantly differ from each other. All characters means were higher significantly for the Blend-2, except taste mean which was the highest significantly in Blend-3. The second order for most characters` means were for Blend-3, followed by Blend 4 then that Blend-1 and finally Blend-5.

Fig. (2) reveals that Blend-2 had the greatest mean in all characters` means and within this blend, the mean of taste was quite low. Both of the means belonging to Blends 3 and 4 almost exhibited narrow differences, but significantly and Blends 1 and 5 had the lowest means respectively.

Table (5) represents the means comparison test with respect to the characters, reheating time and their interaction's means. The characters` means within each character revealed that in all characters as the reheating time was proceeded, the organoleptic score decreased with one only exception, where being in the taste character, the mean of organoleptic treated for 3 hours was higher significantly in comparison with 2 hour reheating time.

Fig. (3) reveales the descending order of the organoleptic as the time of reheating was elongated. Meanwhile, slightly differences among the characters means within each time treatment, were detected, except for the 8 hours, where, the differences extremely disappeared.

Table (6) shows the least significant difference test to compare the second order interaction`s means, among the three factors. For instance, it was clear that within each character, colour was a descending order for the

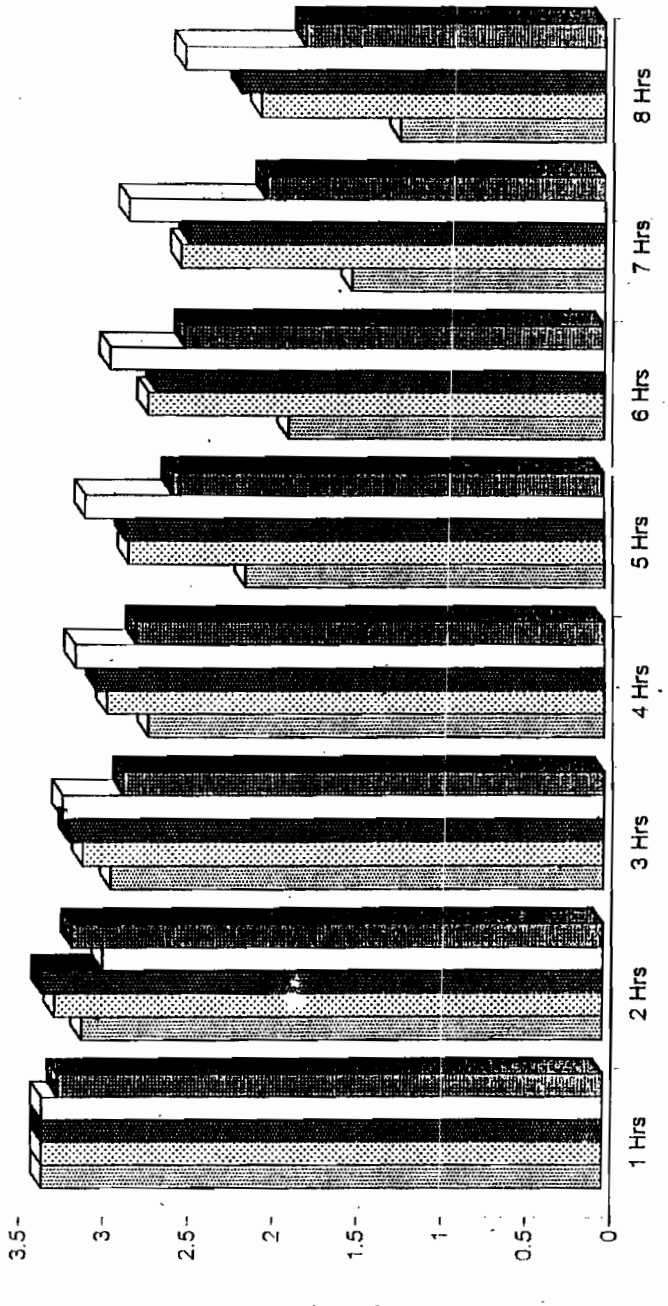

Fig. (1) Effect of frying time on the organoleptic scores of five blends used.

Table (4). The least significant difference test to compare the organoleptic characters , blends' means and the means of the interaction between the both factors .

Organoleptic characters	Blend-1		Blend-2		Blend-3		Blend-4		Blend-5		Org. char. means	
Colour	2.579	C d	3.063	A a	2.817	D c	2.840	B b	2.461	A e	2.752	A
Taste	2.634	A d	2.859	D b	2.882	B a	2.793	C c	2.378	B e	2.709	B
Consistency	2.545	D d	3.006	B a	2.899	A b	2.867	A c	2.242	D e	2.712	B
Odour	2.618	B d	2.999	C a	2.832	C b	2.800	C c	2.262	C e	2.702	B
Blends' means	2.594	d	2.982	a	2.857	b	2.825	c	2.336	e	2.719	

Different letters means that there are significant difference between the means .

Capital letters to the vertical comparison and the small letters to the horizontal one .

LSD (4)$_{(0.05)}$ = 0.00557 LSD (5)$_{(0.05)}$ = 0.00622 LSD (20)$_{(0.05)}$ = 0.01245

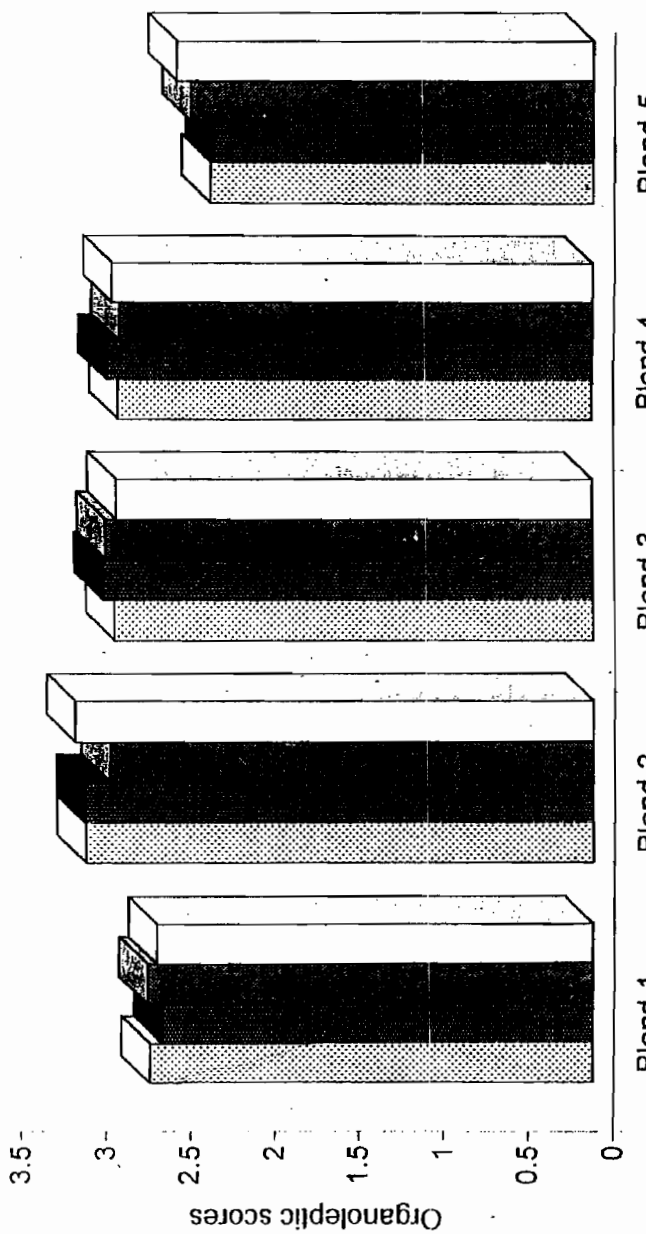

Fig. (2) Effect of the kind of oil blend on four organoleptic characters of the five used blends

Table (5). The least significant difference test to compare the reheating time , organoleptic characters means and the means of the interaction between the both factors.

Organoleptic characters	1- Hrs	2- Hrs	3- Hrs	4- Hrs	5- Hrs	6- Hrs	7- Hrs	8- Hrs	Org. char. means
Colour	3.301 A a	3.255 A b	3.003 C c	2.946 A d	2.688 A e	2.548 AB f	2.309 A g	1.967 B h	2.752 A
Taste	3.301 A a	2.968 C c	3.065 A b	2.859 D d	2.690 A e	2.551 A f	2.248 B g	1.991 A h	2.709 B
Consistency	3.286 B a	3.159 D b	3.044 B c	2.892 C d	2.688 A e	2.533 B f	2.231 C g	1.860 D h	2.712 B
Odour	3.301 A a	3.209 B b	3.047 B c	2.911 B d	2.621 B e	2.438 C f	2.207 D g	1.883 C h	2.702 B
Preheating times' means	3.297 a	3.148 b	3.040 c	2.902 d	2.672 e	2.518 f	2.249 g	1.925 h	2.719

Different letters means that there are significant difference between the means .
Capital letters to the vertical comparison and the small letters to the horizontal comparison .
LSD $(4)_{(0.05)}$ = 0.0055687 LSD $(8)_{(0.05)}$= 0.01707 LSD $(32)_{(0.05)}$ = 0.0157507

0.006226025

0.007875368

0.01245205

0.015750736

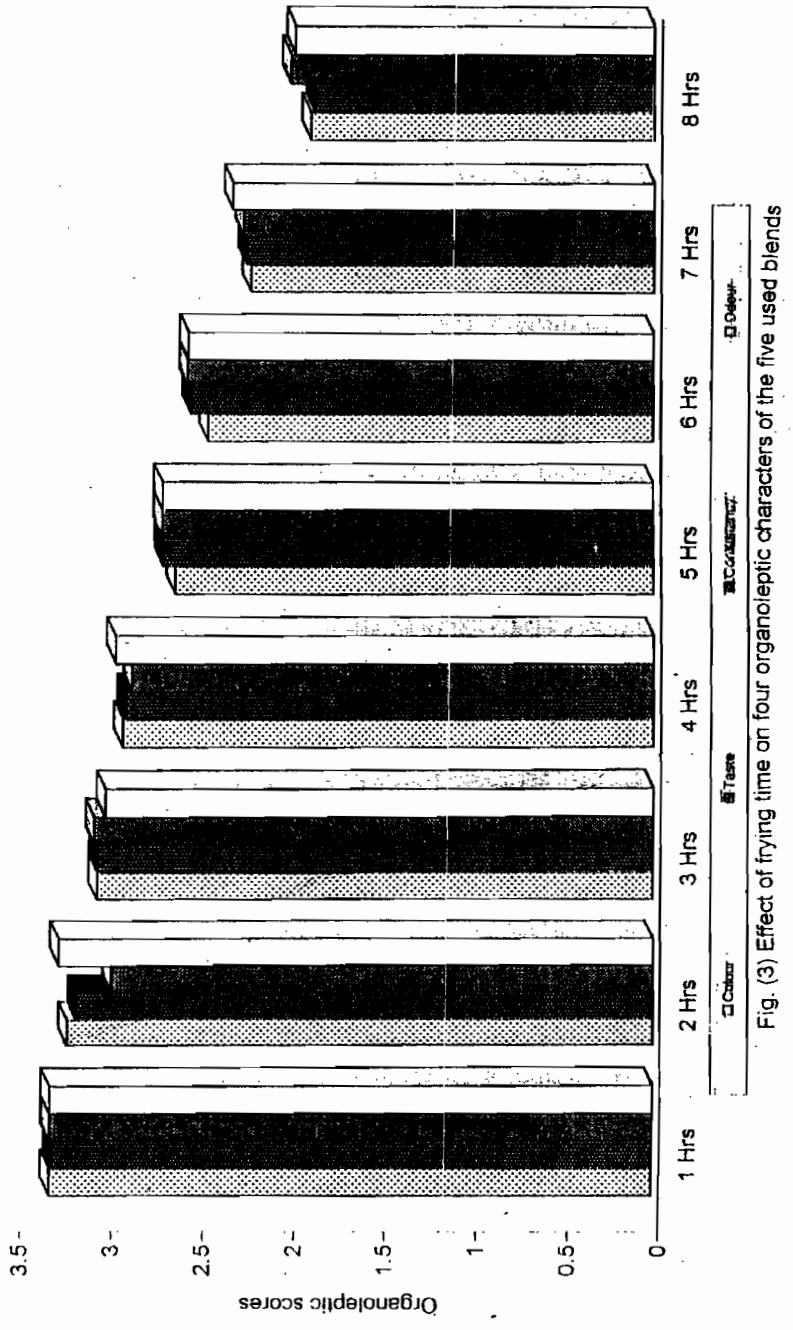

Fig. (3) Effect of frying time on four organoleptic characters of the five used blends

Table (6). The least significant difference test to compare the reheating time , blends', organoleptic characters' means and the means of the interaction among the three factors .

Organo. characters	Time	Blend-1	Blend-2	Blend-3	Blend-4	Blend-5	Time*char mi*ans
Colour	1 Hrs	3.240 Ab	3.317 Aa	3.317 Aa	3.317 Aa	3.317 Aa	3.301 A
	2 Hrs	3.240 Ab	3.240 Bb	3.317 Aa	3.317 Aa	3.162 Bc	3.255 B
	3 Hrs	2.449 Id	3.240 Ba	3.162 Bb	3.162 Cb	3.000 Cc	3.003 G
	4 Hrs	2.739 Fd	3.162 Ca	3.000 Cb	3.000 Db	2.828 Dc	2.946 H
	5 Hrs	2.646 Gc	3.082 Ea	2.646 Ec	2.828 Eb	2.236 Fd	2.688 L
	6 Hrs	2.449 Ic	3.000 Fa	2.645 Eb	2.646 Gb	2.000 Gd	2.548 O
	7 Hrs	2.000 Jc	2.915 Ha	2.449 Gb	2.449 Hb	1.732 Hd	2.309 QR
	8 Hrs	1.871 Kc	2.549 Ja	2.000 Kb	2.000 Jb	1.414 Id	1.967 V
Taste	1 Hrs	3.240 Ab	3.317 Aa	3.317 Aa	3.317 Aa	3.317 Aa	3.301 A
	2 Hrs	3.162 Bc	2.121 Le	3.317 Aa	3.240 Bb	3.000 Cd	2.968 G
	3 Hrs	3.000 Db	3.162 Ca	3.162 Ba	3.000 Db	3.000 Cb	3.065 D
	4 Hrs	2.739 Fd	3.082 Ea	3.000 Cb	2.828 Ec	2.646 Ee	2.859 K
	5 Hrs	2.646 Gd	3.000 Fa	2.828 Db	2.739 Fc	2.236 Fe	2.690 L
	6 Hrs	2.549 Hb	2.915 Ha	2.646 Ec	2.646 Gc	2.000 Gd	2.551 N
	7 Hrs	2.000 Jc	2.828 Ia	2.549 Fb	2.449 Hb	1.414 Id	2.248 R
	8 Hrs	1.732 Lc	2.449 Ka	2.236 Ia	2.121 Ib	1.414 Id	1.991 U
Consistency	1 Hrs	3.162 Bb	3.317 Aa	3.317 Aa	3.317 Aa	3.317 Aa	3.286 A
	2 Hrs	3.000 Dc	3.240 Bb	3.317 Aa	3.240 Bb	3.000 Cc	3.159 C
	3 Hrs	2.828 Ec	3.240 Ba	3.162 Bb	3.162 Cb	2.828 Dc	3.044 F
	4 Hrs	2.739 Fd	3.162 Ca	3.000 Cb	2.915 Dc	2.646 Ee	2.892 J
	5 Hrs	2.449 Id	3.162 Ca	3.000 Cb	2.828 Ec	2.000 Ge	2.688 L
	6 Hrs	2.449 Ib	2.828 Ia	2.828 Da	2.828 Ea	1.732 Hc	2.533 P
	7 Hrs	2.000 Hc	2.646 Ja	2.449 Gb	2.646 Ga	1.414 Id	2.231 S
	8 Hrs	1.732 Ld	2.449 Ka	2.121 Jb	2.000 Jc	1.000 Je	1.860 Y
Odour	1 Hrs	3.240 Ab	3.317 Aa	3.317 Aa	3.317 Aa	3.317 Aa	3.301 A
	2 Hrs	3.162 Bc	3.240 Bb	3.317 Aa	3.162 Cc	3.162 Bc	3.209 B
	3 Hrs	3.082 Cb	3.162 Ca	3.162 Ba	3.000 Dc	2.828 Dd	3.047 E
	4 Hrs	2.828 Ec	3.082 Ea	3.000 Cb	3.000 Db	2.646 Ed	2.911 I
	5 Hrs	2.449 Ic	3.000 Fa	2.828 Db	2.828 Eb	2.000 Gd	2.621 M
	6 Hrs	2.449 Ic	2.915 Ga	2.449 Gc	2.646 Gb	1.732 Hd	2.438 Q
	7 Hrs	2.000 Jd	2.828 Ia	2.345 Hc	2.449 Hb	1.414 Ie	2.207 T
	8 Hrs	1.732 Ld	2.445 Ka	2.236 Ib	2.000 Jc	1.000 Je	1.883 W
Blends'means		2.594 d	2.982 a	2.857 b	2.825 c	2.336 e	2.719

Different letters means that there are significant difference between the means

Capital letters to the vertical comparison and the small letters to the horizontal comparison .

LSD (4)$_{(0.05)}$ = 0.0055687 LSD (5)$_{(0.05)}$=0.0055687 LSD (8)$_{(0.05)}$ =0.0078757 LSD (32)$_{(0.05)}$ =0.0157507 LSD (160)$_{(0.05)}$ = 0.0352197

means of organoleptic score means as the time of reheating oil proceeded for each blends, without exception and these differences were significant in the most cases.

In all the studied characters in the first reheating hour, no significant differences were observed among the five blends except the 1st blend for taste, consistency and odour which were significantly the lowest than the other blends` means. Most of the means in the different characters in the different time of reheating were significantly the greatest in Blend-2, then Blend-3 after that Blend-4, followed by Beind-1 and finally the lowest mean for Blend-5. Regardless to the different blends, the three first treatments had the greatest means and as the reheating time was elongated, the organoleptic scores` means decreased specially for the means due to 8 hour treatment in taste, colour , odour and consistency, respectively. Data explored descending order from one hour to 8 hours treatment. Moreover, quite variations appeared in the 1st 3 time treatments, considerable changes for 4, 5 hour treatments and an extremely difference within each time treatment for each characters among the different blends.

In the light of data presented here, it can be concluded that sensorical quality of potato French fries are significantly deteriorated by frying in reheated oils. It was obvious that as reheating time was elongated, the organoleptic quality was dramatically declined. According to Pokorny (1989). the oil extracted from the fried product contains higher amounts of polymers than the oil remaining in the fryer. Consequently, fresh oils should be used to fry potato fingers to ensure safety and quality of such fried product for the consumer.

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الجودة الحسية لأصابع بطاطس تم تحميرها في زيوت ودهون معادة التسخين

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الملخص العربي

تم تحمير أصابع بطاطس بطريقة التحمير العميق وذلك باستخدام كلا من الزيوت التالية : زيت النخيل ، زيت الذرة ، وزيت دوار الشمس ، والمسلي البلدي ، كذلك فقد أجري تحمير أصابع البطاطس في مخاليط من الزيوت والدهون سالفة الذكر وذلك علي النحو التالي : المخلوط الأول (١زيت نخيل : ٢زيت ذرة : ٣ زيت دوار الشمس : ٤ مسلي) ، المخلوط الثاني (٤ زيت نخيل : ٣ زيت ذرة : ٢ زيت دوار الشمس : ١ مسلي) ، المخلوط الثالث (٢ زيت نخيل : ١ زيت ذرة : ٣ زيت دوار الشمس : ٤ مسلي) ، المخلوط الرابع (٣ زيت نخيل : ٤ زيت ذرة : ١ زيت دوار : ٢ مسلي) المخلوط الخامس (١ زيت نخيل : ٢ زيت ذرة : ٤ زيت دوار الشمس : ٣ مسلي) . وأجريت عملية تسخين مستمرة للزيوت والمخاليط علي مدي ثماني ساعات علي ١٨٠ °م وتم تحمير دفعات من أصابع البطاطس (١٠ دقائق لكل دفعة) وتم تقييم الدفعة الأخيرة/ ساعة من ساعات التحمير بواسطة عشرة من المحكمين المدربين .

وتم تحليل نتائج التقييم الحسي احصائيا باستخدام تحليل الاختلافات لثلاثة عوامل وهي زمن تسخين الزيت و نوع الزيت أو المخلوط و الصفة الحسيه التي يتم تقييمها .

تبين من نتائج التحليل الاحصائي لنتائج الاختبارات الحسية التي أجريت علي أصابع البطاطس المحمرة أنه علي الرغم من وجود بعض الاختلافات في جودة أصابع البطاطس المحمرة في مخاليط زيوت مختلفة إلا أن جودتها الحسية قد تدهورت جوهريا كلما طالت مدة تسخين الزيت أو الدهن وهو الأمر الذي يوضح أهمية استخدام زيوت تحمير طازجة (لم يسبق تسخينها) اذا ما أريد انتاج أصابع بطاطس محمرة عالية الجودة من الوجهه الحسية .